

**OCCURRENCE OF *DIURAPHIS (HOLCAPHIS) FREQUENS*  
(WALKER) (HOMOPTERA: APHIDIDAE) ON  
WHEAT, NEW TO IDAHO, AND A KEY TO  
NORTH AMERICAN *DIURAPHIS***

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*Abstract.*—Colonies of a species of *Diuraphis (Holcaphis)* were found on wheat near Parma, Idaho in 1986. Morphologically, the species best fits the description of *Diuraphis (Holcaphis) frequens* (Walker), though the process terminalis is longer with respect to the base of the sixth antennal segment than is reported for European *D. frequens*. The host range of the Idaho *Diuraphis frequens* is also consistent with that reported for *D. frequens* in Europe, except that the populations found in Idaho multiply much more quickly on wheat than on *Elytrigia repens* (L.) Beauvois. In spite of these differences, we think this *Diuraphis* sp. is *D. frequens*. We do not expect that it will become a serious pest in Idaho.

*Key Words.*—Insecta, Aphididae, *Diuraphis frequens*, *Diuraphis noxia*

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In surveys of wheat (*Triticum aestivum* L.) in 1986, colonies of an unusual *Diuraphis (Holcaphis)* were found near Parma, Idaho. Isolated plants were severely stunted and contorted, their rolled and twisted leaves containing hundreds of wax-covered aphids. The same species was collected in suction trap samples from Parma, Rockland Valley and Arbon in 1986, from Parma in 1988 and 1989, and from Kimberly and Moscow in 1990. We think this aphid is *Diuraphis (Holcaphis) frequens* (Walker). We discuss its identity, based upon morphology and host range. We also compare its ability to colonize the plants with that of *Diuraphis (Diuraphis) noxia* (Mordvilko), which is the only other species of *Diuraphis* known to occur in Idaho, and with *Rhopalosiphum padi* (L.) and *Schizaphis graminum* (Rondani), which are both common pests in the U.S. with wide host ranges among the Gramineae.

METHODS AND MATERIALS

Twenty apterous viviparae from a colony of *D. frequens*, collected in Canyon County, Idaho on *T. aestivum* propagated on *T. aestivum* cv. ID0232, were mounted and measured using a Zeiss compound binocular microscope equipped with an eyepiece micrometer. Two attempts were made to obtain additional specimens from each of two accessions of *Elytrigia repens* (L.) Beauvois, but colonies grew inadequately to produce sufficient adults.

Host plants for each of the described *Diuraphis (Holcaphis)* spp. were obtained including *Calamagrostis* sp., *Agrostis alba* L., *Agrostis palustris* (Hudson) Persoon, *Agrostis tenuis* Sibthorp, *Apera interrupta* (L.) Beauvois (formerly in *Agrostis*), *Holcus lanatus* L., *Bromus inermis* Leys, *Bromus tectorum* L., *Elytrigia repens* (formerly in *Agropyron*), *Agropyron cristatum* (L.) Gaertner, *Thinopyrum ponticum* (Podperae) Barkworth & D. R. Dewey (second time only) and *T. aestivum*.

The plants were started from seed in the autumn of 1987, except for *Calamagrostis* sp., *E. repens*, *B. inermis* and *B. tectorum*, which were transplanted from the field, trimmed and allowed to regrow new shoots that were solely used. Plants were infested 30 Nov–3 Dec 1987 using three pots of each plant species for each of the three species of aphids, including the Idaho *D. frequens*, *D. noxia* and *R. padi*. The infestation rate was ten aphids per plant. On 14 Dec 1987, plants were scored for colonization using the following scale: 1—no aphids, 2—a few solitary aphids, 3—small colonies, 4—plant heavily colonized. After the readings, the plants were cut back and sprayed with Bifenthren (Capture 2EC) (1.26 g a.i./liter), if infestations were found.

On 18–19 Jan 1988, the same plants, with exceptions that *A. interrupta* and the Minnesota accession of *B. inermis* were omitted and *T. ponticum* was added, were infested with 20 aphids per pot in the same manner described above. On 3 Feb 1988, readings were taken as before.

In order to quantitatively determine relative colonization ability, the plants were reinfested in 1989. The same plants (by then more than one year old) were used, except the three *Bromus* accessions and *A. cristatum* (omitted because they had died in the interim), an accession of *E. repens* from Moscow, Idaho (added), and the wheat (about six weeks old). We used three pots of each plant species for each of four species of aphids, including the Idaho *D. frequens*, *D. noxia*, *R. padi* and *S. graminum*. Plants were infested with 20 adult aphids per plant on 30–31 Jan 1989. On 14–15 Feb 1989, the parts of the plants above ground were clipped and placed in Berlése funnels until they dried completely. Aphids were counted using a dissecting microscope. In the case of the wheat, 10% subsamples were counted.

The data were analyzed using the ANOVA and LSD mean separation procedures (0.05 significance level) in SAS software (SAS Institute 1985). Because plant and aphid species interactions were significant, the species were analyzed separately. The data were analyzed using a transformation to normalize the variance ( $Y = \sqrt{\text{count} + 0.5}$ ).

## RESULTS AND DISCUSSION

*Morphology.*—The subgenus *Holcaphis* is distinguished from *Diuraphis* s. str. by lack of a supracaudal process, and currently includes six described species: *Diuraphis tritici* (Gillette)<sup>1</sup> (native to North America), *Diuraphis agrostidis* (Muddathir), *Diuraphis bromicola* (Hille Ris Lambers), *Diuraphis calamagrostis* (Ossiannilsson), *Diuraphis frequens* (Walker) and *Diuraphis holci* (Hille Ris Lambers) (Eastop & Hille Ris Lambers 1976). In addition to *D. tritici*, only two species, *D. frequens* and *D. holci*, have been reported from North America (Smith & Parron 1978). The ultimate rostral segment of the Idaho *D. frequens* is 0.069 mm long, as compared with 0.12 mm for *D. tritici*, thus ruling out the possibility that our aphid is *D. tritici*. Hille Ris Lambers (1939) separates European *D. holci* from *D.*

<sup>1</sup> After this article went to press, Zhang et al. (1991) published a review of *Diuraphis* that treats *D. tritici* as a subspecies of *D. frequens*. We prefer to retain these as distinct species until their change can be confirmed by hybridization experiments. Two new *Diuraphis* from China, which are described by Zhang et al. (1991), are not discussed here.



*frequens* using relative lengths of antennal segments III and IV + V, and the ratio of the base of antennal segment VI to the process terminalis. The *D. frequens* found in Idaho will key to *D. frequens* in Hille Ris Lambers (1939), using the former character, and to *D. holci*, using the latter; however, the same was true of five specimens of *D. frequens* collected in Enfield, England on 12 Jul 1987, indicating that the antennal segment VI character is not consistently reliable, even in Europe.

The key by Muddathir (1965) separates the two species using siphuncular placement, and presence or absence of intersegmental muscle insertions and sclerites on abdominal segment VI. Most Idaho material will key to *D. frequens* using Muddathir's key, but the siphunculi on some specimens are slightly closer to the sixth than to the seventh abdominal spiracles, a character given there for *D. holci*.

Of the species in the subgenus not yet reported in North America, *Diuraphis bromicola* was described from *Bromus inermis* (Hille Ris Lambers 1959), and can be separated from *D. holci* and *D. frequens* by the absence of sclerotic areas on the abdomen, other than on abdominal segment VIII. The Idaho specimens have an obvious sclerotic bar on abdominal segment VII, which would appear to rule out *D. bromicola*. *Diuraphis agrostidis* and *D. calamagrostis* have pore-like siphunculi with the siphuncular aperture facing upward, while *D. holci* and *D. frequens* have longer siphunculi, shaped such that the aperture faces posteriorly (Muddathir 1965). *Diuraphis agrostidis* has  $2n = 12$  chromosomes and *D. frequens* has  $2n = 14$  (Blackman 1980). The specimens from Idaho have siphunculi that fit the description of *D. frequens* better than those of *D. agrostidis* and *D. calamagrostis*, and have  $2n = 14$  chromosomes (R. L. Blackman, personal communication).

Occasional specimens of *D. frequens* collected in Idaho have a posteromedial extension on abdominal tergite VIII that suggests a supracaudal process. These specimens can be separated from *Diuraphis (Diuraphis) nodulus* (Richards) and *Diuraphis (Diuraphis) mexicana* (Baker) by the position of the siphunculi in relation to the sixth and seventh abdominal spiracles. Siphunculi of *D. frequens* are clearly between the sixth and seventh spiracles (Muddathir 1965), whereas siphunculi of *D. nodulus* and *D. mexicana* are anterior to the sixth pair of spiracles.

Morphological differences among species found in North America can be summarized by the following key:

KEY TO SPECIES OF *DIURAPHIS* REPORTED IN  
NORTH AMERICA

- |       |  |                 |
|-------|--|-----------------|
| 1.    | Supracaudal process present on apterous viviparae; siphunculi anterior to sixth pair of abdominal spiracles (Fig. 1; also see Fig. 3) [ <i>Diuraphis (Diuraphis)</i> ] . . . . .   | 2               |
| 1'.   | Supracaudal process on apterous viviparae absent or barely indicated; siphunculi between sixth and seventh pair of abdominal spiracles (Fig. 2) [ <i>Diuraphis (Holcaphis)</i> ] . . . . .                                   | 3               |
| 2(1). | Process terminalis of viviparae at least $2.0\times$ as long as base of antennal segment VI; supracaudal process on apterous viviparae fingerlike and at least $1.5\times$ as long as width at the middle (Fig. 1) . . . . . | <i>D. noxia</i> |



Figure 1. *Diuraphis (Diuraphis) noxia* (Mordvilko) apterous vivipara, showing supracaudal process and position of siphunculi with respect to sixth and seventh pairs of abdominal spiracles.

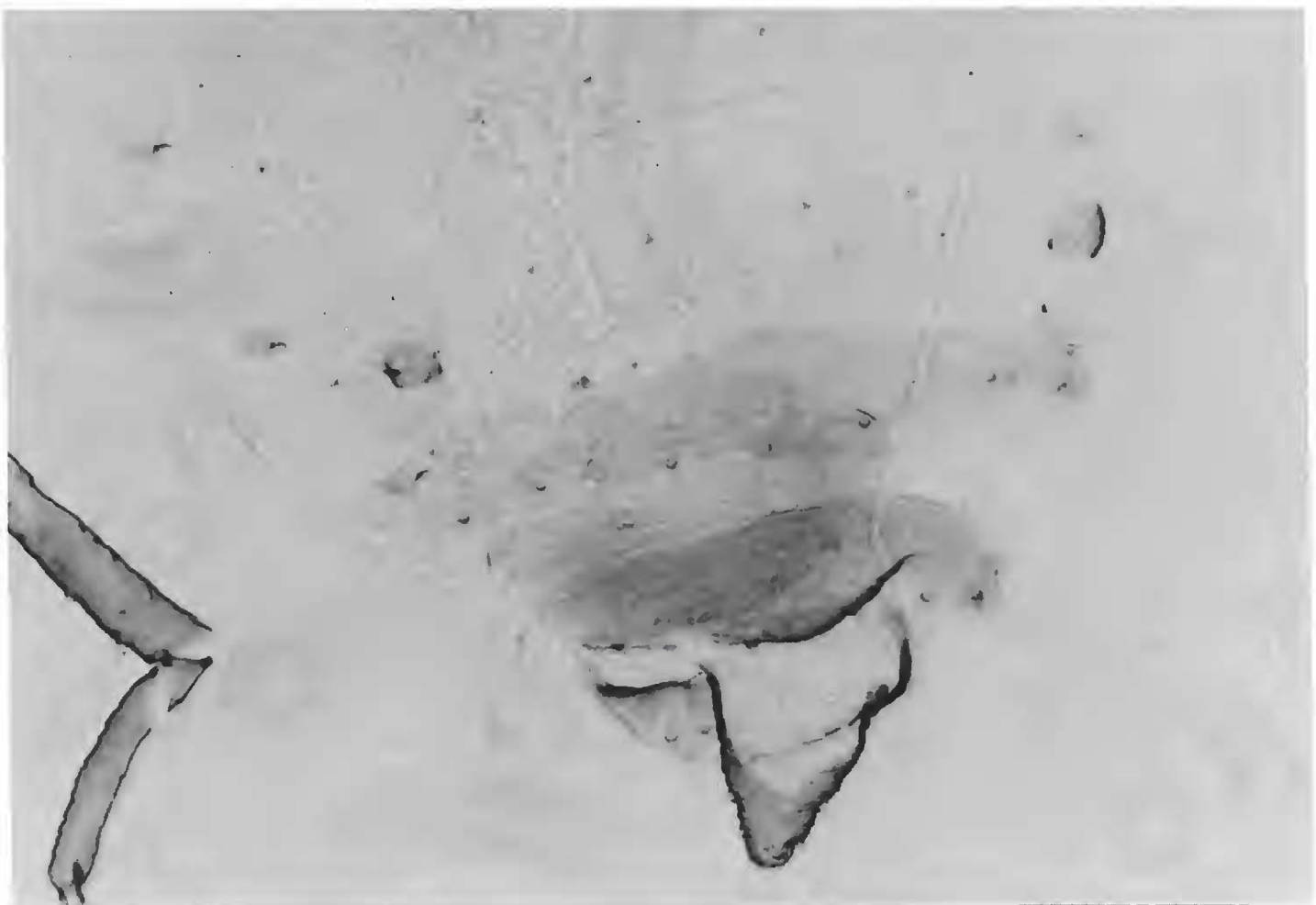


Figure 2. *Diuraphis (Holcaphis) frequens* (Walker) apterous vivipara, showing supracaudal process and position of siphunculi with respect to sixth and seventh pairs of abdominal spiracles.

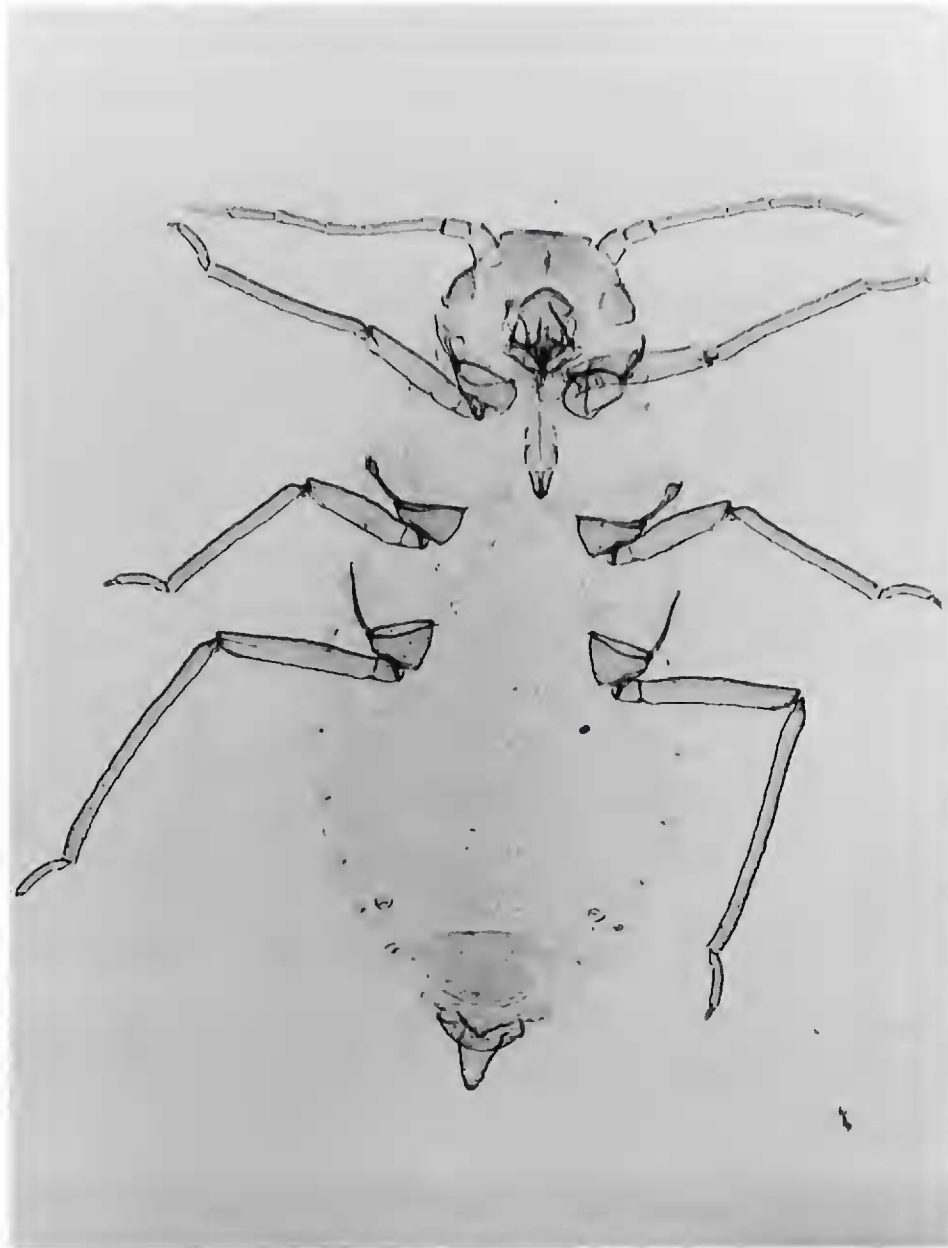


Figure 3. *Diuraphis (Diuraphis) mexicana* (Baker) apterous vivipara, showing supracaudal process, position of siphunculi and length of process terminalis.

- 2'. Process terminalis of apterous viviparae less than  $1.5 \times$  as long as base of antennal segment VI, of alate viviparae less than twice as long as base of VI; supracaudal process on apterous viviparae broad and wider than long, sometimes with a short projection in the center (Fig. 3) ..  
 ..... *D. mexicana* and *D. nodulus*<sup>2</sup>
- 3(1). Ultimate rostral segment of all forms 0.12 mm long and nearly  $3.0 \times$  as long as wide (Fig. 4) ..... *D. tritici*
- 3'. Ultimate rostral segment of all forms 0.07 mm long and  $2.0 \times$  as long as wide (Fig. 5) ..... 4
- 4(3). Clear markings on abdominal segment VI of all viviparae; antennal segment III on apterous viviparae longer than segments IV and V combined; specific to *Holcus* (Fig. 6) ..... *D. holci*
- 4'. No markings on abdominal segment VI of viviparae; antennal segment III on apterous viviparae shorter than segments IV and V combined; on *Agropyron*, *Triticum* and *Elytigia*, but not on *Holcus* (Fig. 7) ...  
 ..... *D. frequens*

<sup>2</sup> Resolution of *D. nodulus* and *D. mexicana* requires further taxonomic study. A revision of *Diuraphis* is pending (Manya B. Stoetzel, personal communication).





Figure 4. *Diuraphis (Holcaphis) tritici* (Gillette) apterous vivipara, showing ultimate rostral segment. Scale: 1 cm = 0.05 mm actual size.

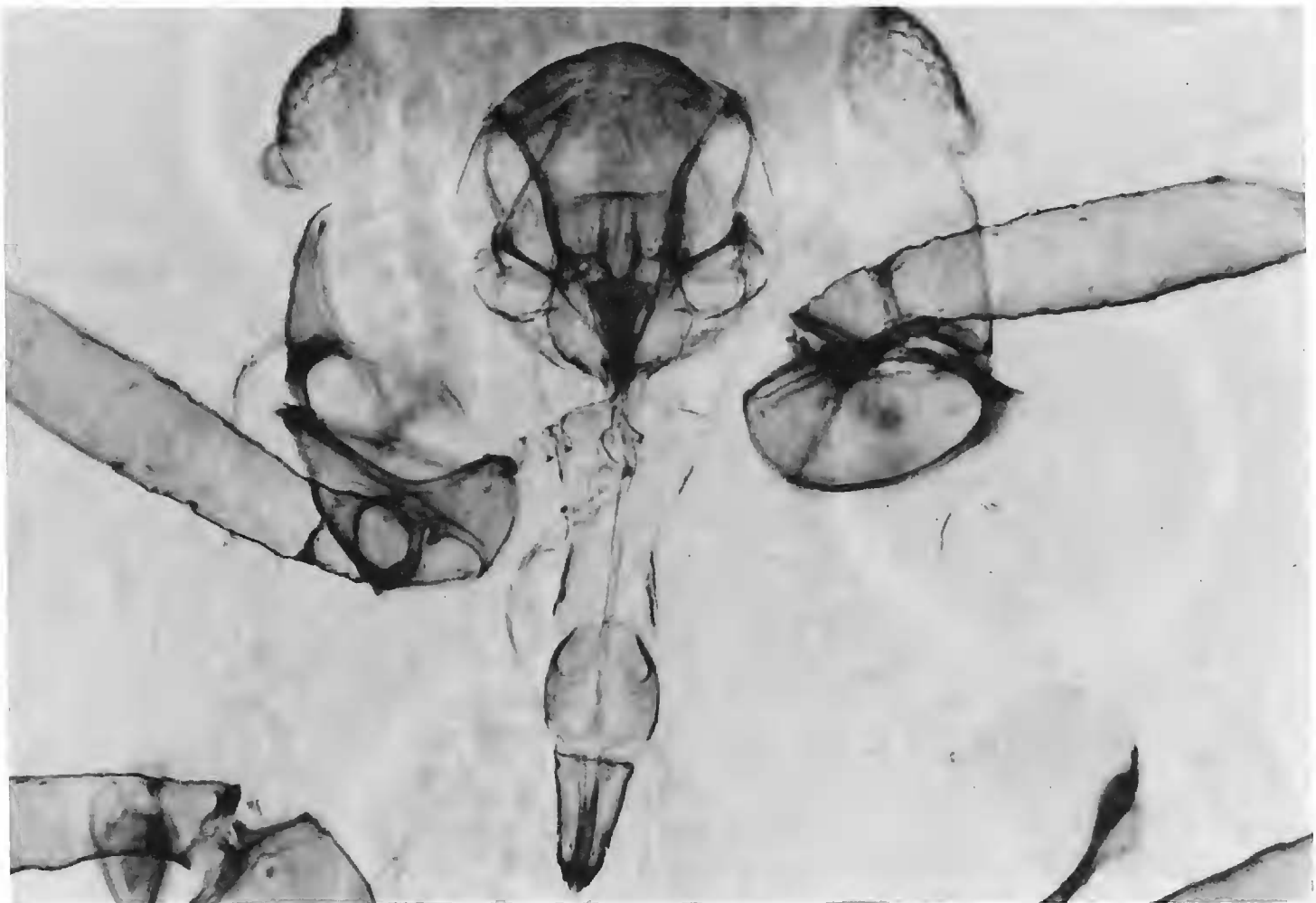


Figure 5. *Diuraphis (Holcaphis) frequens* (Walker) apterous vivipara, showing ultimate rostral segment. Scale: 1 cm = 0.05 mm actual size.

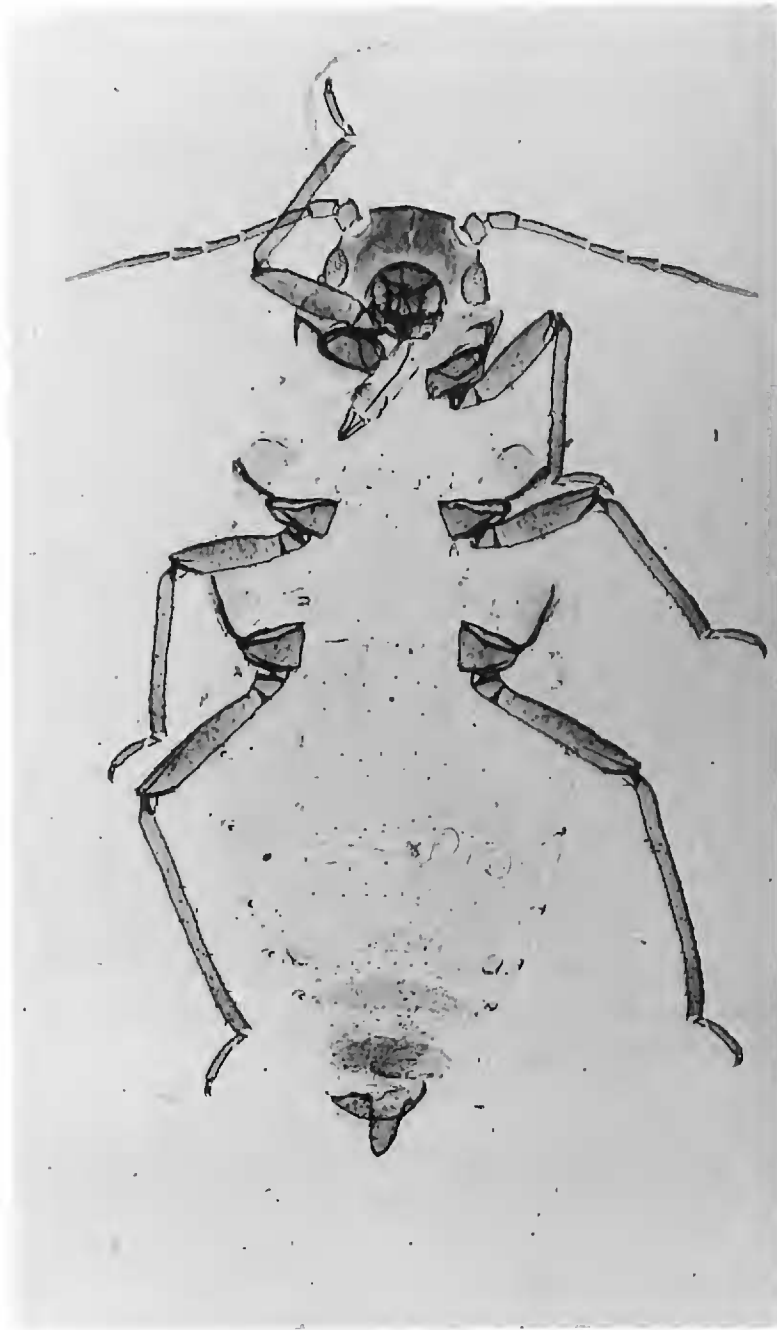


Figure 6. *Diuraphis (Holcaphis) holci* (Hille Ris Lambers) apterous vivipara, showing markings on abdominal segments VI, VII and VIII and relative lengths of antennal segments.

*Host Range.*—In the first experiment, the Idaho *D. frequens* colonized only wheat. In the second experiment, it also heavily colonized *T. ponticum* (not included in the first experiment). No colonies were found on *E. repens* in the first two experiments. In the final experiment, there was heavy colonization on wheat, and smaller colonies were found in *A. interrupta*, *E. repens* and *T. ponticum* (Table 1). This host range fits *D. frequens*, but not *D. holci* or any other *Diuraphis (Holcaphis)* sp. except *D. tritici*, which can be ruled out due to its much longer ultimate rostral segment. We observed that Idaho *D. frequens* placed on *Holcus lanatus* exhibited a toxic reaction; within an hour, the aphids fell off the plants and were unable to move in a coordinated manner. We observed no endophytic fungus in our *H. lanatus* leaves when preparations were made according to the procedure by Saha et al. (1988). Thus, *H. lanatus* is not a host of the Idaho *Diuraphis* sp., ruling out any possibility that it is *D. holci*.

It is, in fact, doubtful that *D. holci* occurs in North America in spite of the records cited by Smith & Parron (1978). There are none in the Canadian national collection in 1989 (Robert Footitt, personal communication), nor in the collection at the Illinois State Natural History Survey in 1990 (David Voegtlin, personal communication), nor in the collections at the California Dept. of Food & Agri-

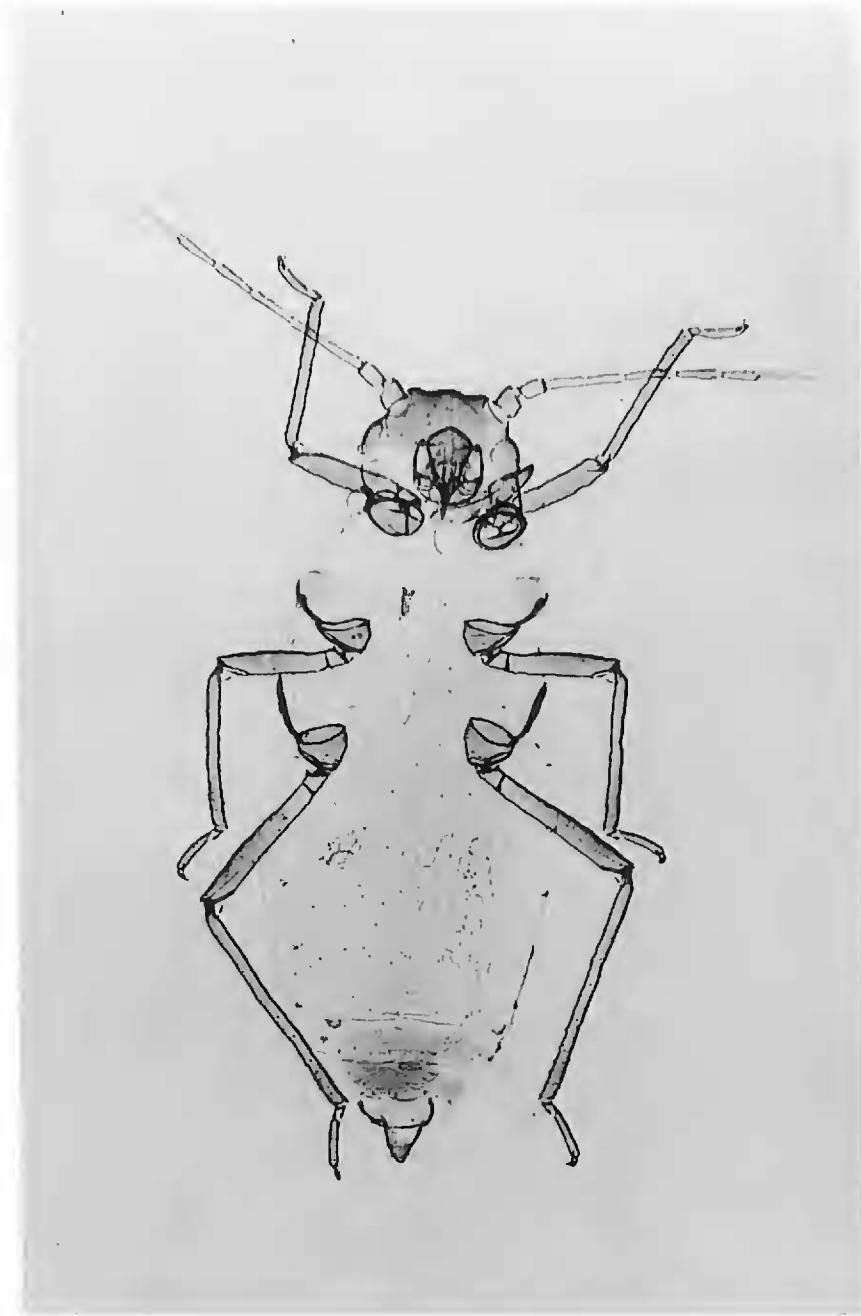


Figure 7. *Diuraphis (Holcaphis) frequens* (Walker) apterous vivipara, showing pattern of abdominal markings and relative lengths of antennal segments.

culture, Sacramento and the University of California, Berkeley, California in 1990 (John Sorensen, personal communication). Hille Ris Lambers (1939) indicated that *D. holci* is restricted to plants in the genus *Holcus*. None of the North American specimens identified as *D. holci* in collections at the United States National Museum or the Palmer Collection at Colorado State University are specified to have been collected from *Holcus*. About half of the slides have inadequate or no host information, but specified host plants include petunia, quackgrass and *Agropyron glaucum*, all unlikely hosts of *D. holci*. Forbes & Chan (1989) reported an extensive survey of aphids in British Columbia where *Holcus lanatus* is abundant. They report *Hyalopteroides humilis* (Walker) and *Sitobion fragariae* (Walker) on *H. lanatus*, but no *Diuraphis* spp. were found. Thus, we are not aware of evidence that any *Diuraphis* sp. colonizing *Holcus* occurs in North America.

*Triticum aestivum* was a better host for the Idaho *D. frequens* than any other plant tested, including *E. repens*, the host reported to be preferred by *D. frequens* in Europe (Hille Ris Lambers 1939) (Table 1); however, colonies on wheat were not as large as those produced by the three pest species. We have not found *D. frequens* on *E. repens* in Idaho, although a number of other aphid species have been found, including *Sipha elegans* del Guercio, *D. noxia*, *Metopolophium dir-*



Table 1. Mean numbers of aphids on various plants after two weeks of colonization, Parma, Idaho, January–February, 1989. Means followed by the same letter (a, b, c) are not significantly different from others in the same column using the LSD method of means separation.

Host	<i>D. frequens</i>	<i>D. noxia</i>	<i>S. graminum</i>	<i>R. padi</i>
<i>Triticum aestivum</i> L.	119.0 a	1816.7 a	2793.3 a	1450.0 a
<i>Apera interrupta</i> (L.) Beauvois	31.3 b	42.7 bc	304.3 b	112.3 b
<i>Elytrigia repens</i> (L.) Beauvois (Moscow, Idaho)	6.3 c	94.0 b	57.7 bc	7.3 c
<i>Elytrigia repens</i> (L.) Beauvois (Caldwell, Idaho)	9.0 c	31.0 bc	31.0 bc	36.0 bc
<i>Agrostis alba</i> L.	0 c	0.3 c	12.0 bc	118.7 b
<i>Agrostis tenuis</i> Sibthorp	0 c	0.3 c	38.0 bc	3.0 c
<i>Agrostis palustris</i> (Hudson) Persoon	0 c	0 c	4.3 c	3.7 c
<i>Holcus lanatus</i> L.	0 c	0 c	5.0 c	7.0 c
<i>Thinopyrum ponticum</i> (Podperae) Barkworth & D. R. Dewey	2.3 c	0 c	2.7 c	0 c
<i>Calamagrostis</i> sp.	0 c	0 c	71.7 bc	0 c

*hodum* (Walker), *Sitobion avenae* (Fabr.), *S. graminum* and *Forda marginata* Koch (Gittins et al. 1976; SEH, unpublished data).

The Idaho *D. frequens*, *D. noxia* and *R. padi* all colonized *T. ponticum*, a species used in conservation plantings, much more heavily when the plants were young than they did one year later. This observation suggests that some perennial grasses may become less palatable to aphids over time. If so, mature conservation plantings pose fewer problems as reservoirs of aphid pests than young stands. This question should be examined further.

*Apera interrupta* was usually colonized more heavily than *Agrostis* spp. This supports recent botanical evidence that *A. interrupta* should not be placed in the genus *Agrostis* as it has sometimes been in the past (McNeill 1981, Hitchcock & Cronquist 1973).

Based on morphology and host range analysis, we think the *Diuraphis* sp. found on Idaho wheat is *D. frequens*, although slight differences in morphology and host preference remain to be resolved. These differences could be due to founder effect, because it is likely that very few individuals were originally introduced into North America.

Other species that have been introduced into North America have host ranges that differ from their parent populations. Probably the most famous example is *Therioaphis trifolii* (Monell). According to Blackman (1981), the original North American population fed on *Trifolium*. About 70 years later, *T. trifolii* forma “*maculata*” (Buckton) appeared on alfalfa. This population has several traits that are not typical of the parent population in the Old World. Evidence suggests that the North American alfalfa population resulted from the introduction of a single clone (Blackman 1981).

In the case of *D. frequens*, however, introduction of a single clone from Europe may not explain the marked preference for wheat in Idaho, because wheat is not considered to be a host of *D. frequens* in Europe. Another possible explanation is that Idaho *D. frequens* came from Asia, across the Bering Strait, rather than from Europe, and thus has a host range differing from European populations; however, wheat is not listed as a host in western Siberia (Ivanovskaya 1977).

We have observed wheat plants colonized by this species each year. Infested plants are usually severely damaged, but damage is restricted to isolated plants. We have observed that the most common situation is to find several infested

plants near the edge of a late maturing field of spring wheat. Laboratory cultures of the Idaho *D. frequens* do not produce many alatae in comparison with *D. noxia* and *D. tritici*. If the same is true for field populations, this could explain its restricted distribution. Theoretically, given the right conditions (e.g., when alate production is greatly increased), outbreaks could occur, but it is unlikely that the species will become a serious pest.

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#### LITERATURE CITED

- Blackman, R. L. 1980. Chromosome numbers in the Aphididae and their taxonomic significance. *Syst. Entomol.*, 5: 7–25.
- Blackman, R. L. 1981. Species, sex and parthenogenesis in aphids. pp. 75–85. *In* Greenwood, P. H. & P. L. Forey (eds.). *The evolving biosphere*. British Museum of Natural History, London.
- Eastop, V. F. & D. Hille Ris Lambers. 1976. *Survey of the world's aphids*. Junk, The Hague.
- Forbes, A. R. & C. K. Chan. 1989. *Aphids of British Columbia*. Agriculture Canada Technical Bulletin, 1989-1E.
- Gittins, A. R., G. W. Bishop, G. F. Knowlton & E. J. Parker. 1976. An annotated list of the aphids of Idaho. *Idaho Agr. Exp. Stat. Res. Bull.*, 95.
- Hille Ris Lambers, D. 1939. On some western European aphids. *Zool. Med. Mus. Leiden*, 22: 79–199.
- Hille Ris Lambers, D. 1959. Notes on European aphids with descriptions of new genera and species (Homoptera, Aphididae). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*, 32: 271–286.
- Hitchcock, C. L. & A. Cronquist. 1973. *Flora of the Pacific northwest*. University of Washington Press, Seattle, Washington.
- Ivanovskaya, O. I. 1977. *Aphids of western Siberia, Volume II*. USSR Academy of Science, "Science" Publishers, Novosibirsk.
- McNeill, J. 1981. *Apera*, silky-bent or windgrass, an important seed genus recently discovered in Ontario, Canada. *Can. J. Plant Sci.*, 61: 479–485.
- Muddathir, K. 1965. A new species of *Holcaphis* (Homoptera: Aphididae) together with a key to the British Species. *Ann. Mag. Nat. Hist.*, 8: 477–485.
- Saha, D. C., M. A. Jackson & J. M. Johnson-Cicalese. 1988. A rapid straining method for detection of endophytic fungi in turf and forage grasses. *Phytopath.*, 78: 237–239.
- SAS Institute. 1985. *SAS user's guide: statistics*. SAS Institute, Cary, N.C.
- Smith, C. F. & C. S. Parron. 1978. An annotated list of Aphididae (Homoptera) of North America. *North Carolina Agricultural Experiment Station Technical Bulletin*, 255.
- Zhang, G.-X., W.-Y. Zhang & T.-S. Zhong. 1991. A review of *Diuraphis* Aizenberg with descriptions of two new species (Homoptera: Aphidoidea). *Scientific Treatise on Systematic and Evolutionary Zoology*, 1: 121–133.

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